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(54) **RADAR ASSEMBLY WITH ULTRA WIDE BAND WAVEGUIDE TO SUBSTRATE INTEGRATED WAVEGUIDE TRANSITION**

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G01S 13/02 (2006.01)

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See application file for complete search history.

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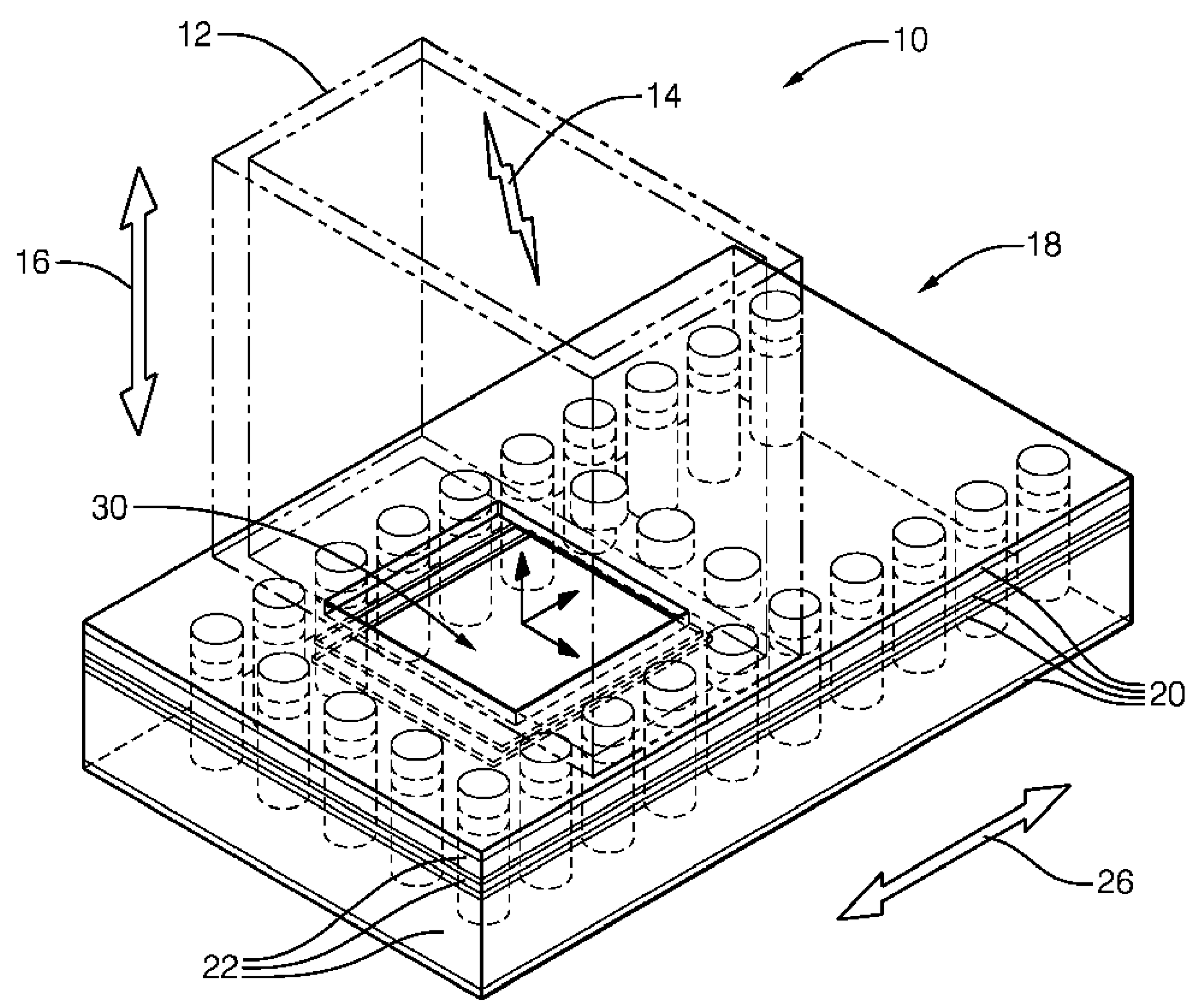
(57) **ABSTRACT**

A radar assembly includes a rectangular-waveguide (RWG) and a printed-circuit-board. The rectangular-waveguide (RWG) propagates electromagnetic energy in a transverse electric mode (TE**10**) and in a first direction. The printed-circuit-board includes a plurality of conductor-layers oriented parallel to each other. The printed-circuit-board defines a substrate-integrated-waveguide (SIW) that propagates the electromagnetic energy in a transverse electric mode (TE**10**) and in a second direction perpendicular to the first direction, and defines a transition that propagates the electromagnetic energy between the rectangular-wave-guide and the substrate-integrated-waveguide. The transition includes apertures defined by at least three of the plurality of conductor-layers.

4 Claims, 2 Drawing Sheets



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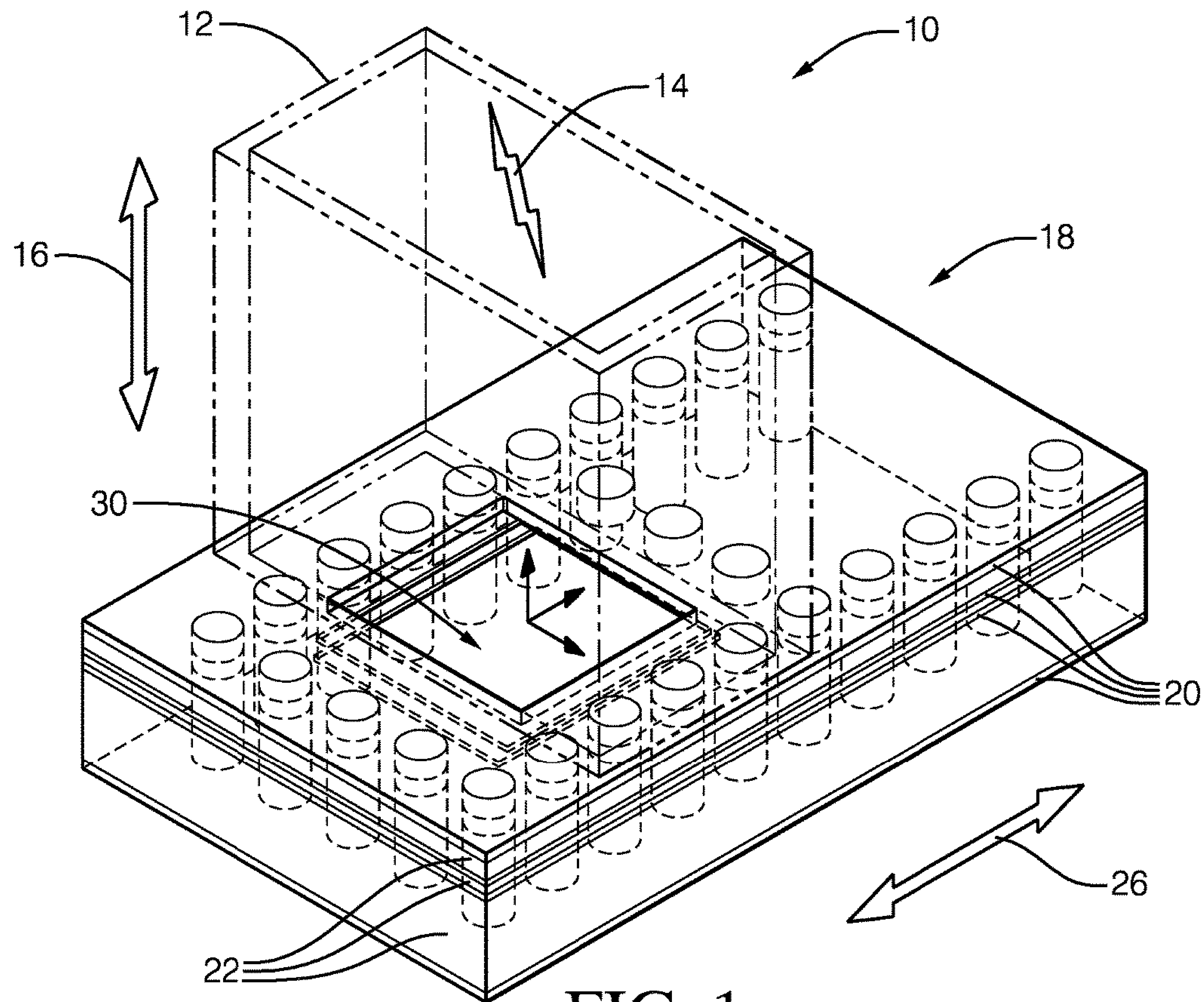


FIG. 1

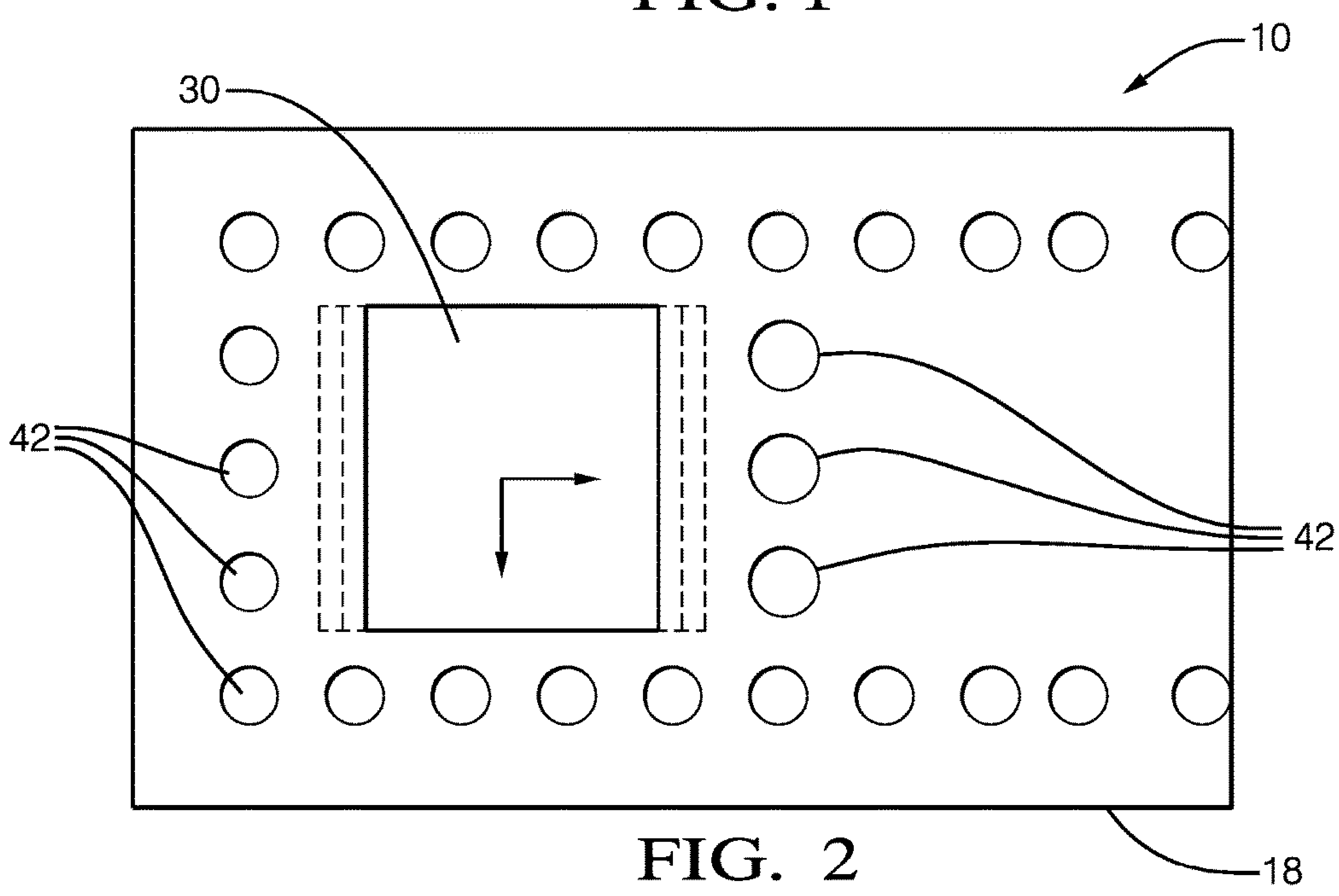
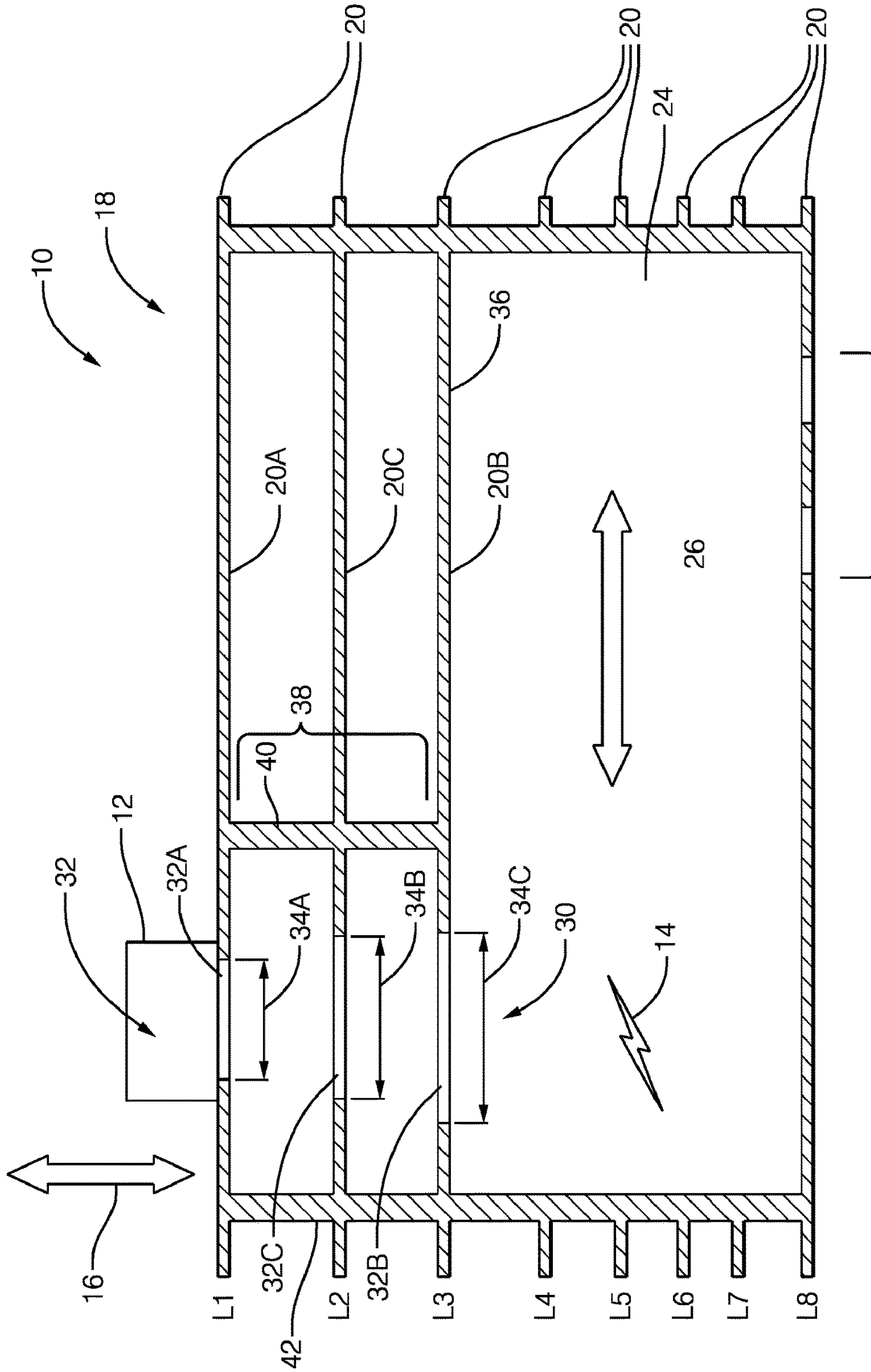


FIG. 2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L1
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L7
L8

FIG. 3

RADAR ASSEMBLY WITH ULTRA WIDE BAND WAVEGUIDE TO SUBSTRATE INTEGRATED WAVEGUIDE TRANSITION

TECHNICAL FIELD OF INVENTION

This disclosure generally relates to a radar assembly, and more particularly relates to a transition between a rectangular-waveguide (RWG) and a substrate-integrated-waveguide (SIW) where the transition includes apertures defined by at least three of a plurality of conductor-layers of a printed circuit board that also defines the SIW.

BACKGROUND OF INVENTION

Wideband Transitions are used in wide band radar systems such as Automotive Radar. Known transitions with sufficient bandwidths include undesirably expensive waveguide flanges or metal structures, where critical tolerances add to the cost.

SUMMARY OF THE INVENTION

Described herein is a wideband transition that is formed using standard printed circuit board (PCB) processes, so is able to avoid using expensive waveguide flanges or metal structures. The non-limiting example described herein provides a transition between a Rectangular Waveguide (RWG) to a Substrate Integrated Waveguide (SIW) suitable for use with, for example, electromagnetic energy having a 16 GHz bandwidth around a 79 GHz fundamental frequency. The transition is suitable for compact multilayer printed circuit board (PCB) construction like Ultra Short Range Radar (USRR), using standard PCB fabrication processes.

In accordance with one embodiment, a radar assembly is provided. The assembly includes a rectangular-waveguide (RWG) and a printed-circuit-board. The rectangular-waveguide (RWG) propagates electromagnetic energy in a transverse electric mode (TE**10**) and in a first direction. The printed-circuit-board includes a plurality of conductor-layers oriented parallel to each other. The printed-circuit-board defines a substrate-integrated-waveguide (SIW) that propagates the electromagnetic energy in a transverse electric mode (TE**10**) and in a second direction perpendicular to the first direction, and defines a transition that propagates the electromagnetic energy between the rectangular-wave-guide and the substrate-integrated-waveguide. The transition includes apertures defined by at least three of the plurality of conductor-layers.

Further features and advantages will appear more clearly on a reading of the following detailed description of the preferred embodiment, which is given by way of non-limiting example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will now be described, by way of example with reference to the accompanying drawings, in which:

FIG. **1** is an isometric view of a radar assembly in accordance with one embodiment;

FIG. **2** is top view of part of the radar assembly of FIG. **1** in accordance with one embodiment; and

FIG. **3** is sectional side view of part of the radar assembly of FIG. **1** in accordance with one embodiment.

DETAILED DESCRIPTION

FIG. **1**, FIG. **2**, and FIG. **3** cooperate to illustrate a non-limiting example of a radar assembly **10**, hereafter referred to as the assembly **10**. The assembly **10** may be part of a larger radar system (not shown), where the assembly **10** provides a transition means between different types of waveguides used to propagate electromagnetic energy in the radar system from one location to another location.

The assembly **10** includes a rectangular-waveguide **12** or RWG **12** that propagates the electromagnetic energy **14** in a transverse electric mode (TE**10**) and in a first direction **16**. The first direction **16** is illustrated as a double-ended arrow because, as will be recognized by those in the art, the RWG **12** can be used to propagate the electromagnetic energy **14** into (i.e. towards) the assembly **10**, or out of (i.e. away from) the assembly **10**. The physical size of the RWG **12** is selected based on the operating frequency of the radar system using well-known design rules.

The assembly **10** also includes a printed-circuit-board **18** that includes a plurality of conductor-layers **20** oriented parallel to each other. The physical dimensions and materials used for dielectric-layers **22** and the plurality of conductor-layers **20** are selected based on the operating frequency of the radar system using well-known design rules. By way of example and not limitation, the plurality of conductor-layers **20** may include eight conductor layers: L**1**, L**2**, L**3**, L**4**, L**5**, L**6**, L**7**, and L**8** (FIG. **3**). Some of these conductor layers (e.g. L**3**-L**8**) may be configured (e.g. processed using known photo-etching techniques) to define a substrate-integrated-waveguide **24** or SIW **24** that propagates the electromagnetic energy **14** in or using a transverse electric mode (TE**10**) to propagate the electromagnetic energy **14** in a second direction **26** perpendicular to the first direction **16**. In this example layer L**8** is further configured to define a slot-radiator **28** that may be used to couple the electromagnetic energy **14** from the SIW **24** to, for example, and antenna (not shown).

The assembly **10**, or more specifically the printed-circuit-board **18**, also includes or defines a transition **30** that propagates the electromagnetic energy **14** between the rectangular-wave-guide **12** and the substrate-integrated-waveguide **24**. As noted above, it is contemplated that the electromagnetic energy **14** could be in either direction; either from the rectangular-wave-guide **12** to the substrate-integrated-waveguide **24**, or from the substrate-integrated-waveguide to the rectangular-wave-guide **12**. The transition **30** includes a plurality of apertures **32** defined by at least three (e.g. L**1**-L**3**) of the plurality of conductor-layers **20**. That is, the transition **30** includes or is defined by at least three instances of apertures. In this example, the transition **30** includes or is defined by a first layer **20**A (L**1**) of the plurality of conductor-layers **20** that is adjacent to or in contact with the rectangular-waveguide **12**. The first layer **20**A defines a first aperture **32**A characterized by a first-size **34**. The transition **30** also includes a last layer **20**B (L**3**) of the plurality of conductor-layers **20** that is adjacent to the substrate-integrated-waveguide **24**, where the last layer **20**B also defines a horizontal-boundary **36** of the substrate-integrated-waveguide **24**. With respect to the transition **30**, the last layer **20**B defines a last aperture **32**B characterized by a last-size **34**B that is greater than the first-size **34**A.

The transition **30** also includes or is defined by one or more instances of an intermediate layer **20**C of the plurality of conductor-layers **20** located between the first layer **20**A and the last layer **20**B of the transition **30**. The intermediate layer **20**C defines an intermediate aperture **32**C characterized by an intermediate-size **34**C with a value between the last-size **34**B and the first-size **34**A. It is contemplated that the transition **30** could have more than a single instance of the intermediate layer **20**C between the first layer **20**A and the last layer **20**B so that the transition **30** would include or be formed by more than three instances of the apertures **32**. That is, it is contemplated that the transition **30** could consist of additional apertures in addition to the intermediate aperture **32**C between the first aperture **32**A and the last aperture **32**B. The progression or variation of the sizes of the apertures **32** may be determine or optimized using known design techniques. For example, the dimensions of the apertures **32** may be optimized on 3D-EM software HFSS for efficient transfer of energy and impedance matching between the RWG **12** and the SIW **24** over wide frequency range.

In order to reduce the amount of the electromagnetic energy **14** that leaks out of the transition **30** so is not communicated between the rectangular-wave-guide **12** and the substrate-integrated-waveguide **24**. The transition **30** may also include one or more instances of a short wall **38** that serves to define a vertical-boundary **40** of the transition **30**. The short wall **38** may be formed of an arrangement of vias **42**, which may be part of the vias **42** used to define the SIW **24**.

Accordingly, a radar assembly (the assembly **10**) is provided. The assembly **10** provides a wideband transition (the transition **30**) between the rectangular waveguide **12** (RWG **12**) to the substrate integrated waveguide **24** (SIW **24**) using the inner layers of a multilayer PCB (printed-circuit-board **18**) for operation in the W-band of the electromagnetic spectrum. The transition is formed by a series of apertures through conductive layers (e.g. L**1** thru L**3**). The transition **30** is advantageously and economically provided by using a multi-layered PCB processed using standard PCB processing technology typically used for the W-band. As such, no special flanges or metal structures are necessary, so the expense and critical tolerances associated features are avoided.

While this invention has been described in terms of the preferred embodiments thereof, it is not intended to be so limited, but rather only to the extent set forth in the claims that follow.

I claim:

1. An assembly comprising:

a rectangular-waveguide (RWG) that propagates electromagnetic energy in a transverse electric mode TE**10** and in a first direction; and

a printed-circuit-board that includes a plurality of conductor-layers oriented parallel to each other, said printed-circuit-board defines a substrate-integrated-waveguide (SIW) that propagates electromagnetic energy in a transverse electric mode TE**10** and in a second direction perpendicular to the first direction, and defines a transition that propagates the electromagnetic energy between the rectangular-wave-guide and the substrate-integrated-waveguide, wherein the transition includes apertures defined by at least three of the plurality of conductor-layers.

2. The assembly in accordance with claim **1**, wherein a first layer of the plurality of conductor-layers is adjacent the rectangular-waveguide, said first layer defines a first aperture characterized by a first-size, and a last layer of the plurality of conductor-layers is adjacent to the substrate-integrated-waveguide and defines a horizontal-boundary of the substrate-integrated-waveguide, said last layer defines a last aperture characterized by a last-size greater than the first-size.

3. The assembly in accordance with claim **2**, wherein an intermediate layer of the plurality of conductor-layers is located between the first layer and the last layer of the transition, said intermediate layer defines an intermediate aperture characterized by an intermediate-size between the last-size and the first-size.

4. The assembly in accordance with claim **1**, wherein the transition includes a short-wall that defines a vertical-boundary of the transition.

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